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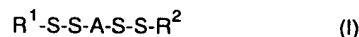
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(54) **RUBBER COMPOSITION AND PNEUMATIC TIRE MADE WITH THE SAME**

(57) The present invention provides a rubber composition improved in the heat resistance, which is suitable for a reinforcing rubber for tire sidewall portions and a bead filler rubber. Also, provided is a pneumatic tire produced using the rubber composition. The rubber composition comprises (A) a natural rubber and/or a synthetic diene rubber and (B) at least one compound selected from the group consisting of a compound represented by the following Formula I:



wherein A represents an alkylene group having 2 to 10 carbon atoms, and R¹ and R² each independently represents a monovalent nitrogen-containing organic group; a citraconimide compound; and an acrylate compound. The pneumatic tire has a rubber layer for reinforcing tire sidewall and/or a bead filler each made of the rubber composition.

DescriptionTechnical Field

5 [0001] The present invention relates to a rubber composition and to a pneumatic tire made of the rubber composition. More specifically, the present invention also relates to a heat-resistant rubber composition suitable as a sidewall reinforcing rubber and a bead filler rubber for tires, and to a pneumatic tire having a sidewall reinforcing rubber layer and a bead filler made of the rubber composition.

10 Background Art

[0002] Stiffness of a sidewall portion of a tire has been enhanced by providing a reinforcing layer made of a rubber composition alone or a composite of a rubber composition and fibers, etc. A rubber composition conventionally used for such purposes is, however, likely to suffer from breaking of the crosslinking bridge formed by vulcanization, etc. or polymer chain scission of a polymer constituting the rubber component when, particularly, the temperature of the tire is elevated to 200 °C or higher during, for example, so-called runflat operation where the tire is operated under a lowered internal inflation pressure due to puncture, etc. These breakings reduce the elasticity of the rubber composition to deflect the tire largely, this promoting the heat generation of the tire and lowering the break limit of the rubber. As a result thereof, the tire failure occurs in relatively short period of use.

20 [0003] To elongate the service life of a tire before its failure, conventionally employed is a method of preventing the heat generation of the rubber composition by changing the formulation thereof so as to make the elasticity of the rubber composition as large as possible or the loss tangent ($\tan \delta$) as small as possible. However, the approach by changing the formulation produces only limited results. Therefore, in order to ensure a higher runflat durability, it has been inevitable to increase the amount of side reinforcing layer and/or bead filler. This, however, brings about disadvantages such as loss of ride performance and unacceptable noise levels during usual tire operations, and increase in weight.

Disclosure of Invention

30 [0004] In view of the above problems in the prior art, a first object of the present invention is to provide a rubber composition having an improved heat-resistance, and suitable particularly for a reinforcing rubber for tire sidewall portions and for a tire bead filler rubber.

[0005] A second object of the present invention is to provide a pneumatic tire made of, at least in part, the rubber composition, particularly, a pneumatic tire showing an excellent durability during runflat operations.

35 [0006] As a result of extensive study in view of attaining the above objects, the inventors have found that a rubber composition containing a specific compound is excellent in heat resistance and is suitable for the sidewall reinforcing rubber and for the bead filler rubber for tires. The inventors have further found that a pneumatic tire having its sidewall reinforcing rubber layer and/or bead filler made of the rubber composition is excellent in the durability, particularly, during runflat operation. The invention has been accomplished on the basis of these findings.

40 [0007] Thus, the invention provides a rubber composition comprising (A) a natural rubber and/or a synthetic diene rubber and (B) at least one compound selected from the group consisting of a compound represented by the following Formula I:



45

wherein A represents an alkylene group having 2 to 10 carbon atoms, R^1 and R^2 each independently represents a monovalent nitrogen-containing organic group; a citraconimide compound; and an acrylate compound.

[0008] The invention also provides:

- 50 (1) the rubber composition wherein A of Formula I for the component B is hexamethylene group;
 (2) the rubber composition wherein each of R^1 and R^2 of Formula I for the component B preferably contains at least one aromatic ring in addition to nitrogen atom;
 (3) the rubber composition wherein the citraconimide compound for the component B is preferably a biscitraconimide compound;
 55 (4) the rubber composition wherein the acrylate compound for the component B is preferably a multifunctional ester compound obtained by the reaction of a polyhydric alcohol with acrylic acid, or by the reaction of a polyhydric alcohol with acrylic acid and another carboxylic acid; and

(5) the rubber composition comprising, as the component B, at least two compounds selected from the group consisting of the compound represented by the following Formula I:



wherein A is an alkylene group having 2 to 10 carbon atoms, R^1 and R^2 are each independently a monovalent nitrogen-containing organic group; a citraconimide compound; and an acrylate compound.

[0009] The invention further provides a pneumatic tire having a pair of right and left ring bead cores, a bead filler provided radially outward of each of the bead cores, a carcass layer comprising at least one ply which comprises a plurality of parallel cords embedded in a coating rubber, a belt layer provided radially outward of the carcass layer, a tread portion provided radially outward of the belt layer, a pair of sidewall portions provided at both right and left lateral edges of the tread portion, and a reinforcing rubber layer provided at the sidewall portions, the reinforcing rubber layer for the sidewall portions and/or the bead filler being made of the rubber composition defined above.

Brief Description of Drawings

[0010] Fig. 1 is a partial cross-sectional view of a pneumatic tire of the present invention.

[0011] Reference numeral 1 is a pneumatic tire, 2 is a carcass layer, 2a is a turned-up carcass ply, 2b is a down carcass ply, 3 is a belt layer, 4 is a bead core, 5 is a bead filler, 6 is a sidewall portion, 7 is a reinforcing rubber layer, and 8 is a tread portion.

Best Mode for Carrying Out the Invention

[0012] The rubber composition of the present invention contains a natural rubber and/or a synthetic diene rubber as the component A. Example of the synthetic diene rubber includes synthetic polyisoprene rubber (IR), polybutadiene rubber (BR), styrene-butadiene rubber (SBR), acrylonitrile-butadiene rubber (NBR), chloroprene rubber (CR), and butyl rubber (IIR). The natural rubber and the synthetic diene rubbers may be used as the component A singly or in combination of two or more.

[0013] To improve the heat resistance of the rubber composition, it is necessary to compound, as the component B, at least one compound selected from the group consisting of the compound represented by Formula I, the citraconimide compound, and the acrylate compound.

[0014] The improvement of the heat resistance of the rubber composition by the component B may be attributable to the function of the component B of efficiently forming more heat-resistant monosulfide linkages or C-C linkages, while a linkage between rubber polymers is broken at high temperatures.

[0015] The compounds for the component B will be described in more detail below.

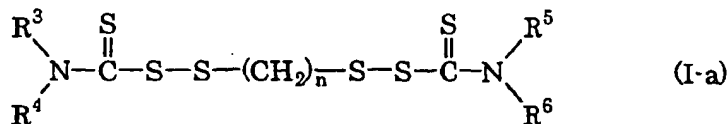
[0016] In the compound represented by Formula I:



A is an alkylene group having 2 to 10 carbon atoms. The alkylene group may be linear, branched or cyclic, with a linear alkylene group being preferred. Examples of the alkylene group having 2 to 10 atoms include ethylene group, trimethylene group, tetramethylene group, pentamethylene group, hexamethylene group, heptamethylene group, octamethylene group, and decamethylene group, with hexamethylene group being preferred in view of obtaining the effect of the present invention.

[0017] Each of R^1 and R^2 is a monovalent nitrogen-containing organic group, preferably a monovalent nitrogen-containing organic group having at least one aromatic group, and more preferably a group containing =N-C(=S)- linkage which bonds to a dithio group through its carbon atom. R^1 and R^2 may be the same as or different from each other, and preferably the same in view of easy synthesis.

[0018] A preferred compound represented by Formula I is, for example, an α,ω -bis(N,N'-dihydrocarbylthiocarbamoyldithio)alkane represented by the following Formula I-a.



[0019] In Formula I-a, each of R³ to R⁶ is an alkyl group, an aryl group or an aralkyl group with the proviso that at least one of R³ and R⁴ and at least one of R⁵ and R⁶ are an aryl group or an aralkyl group, and n is an integer from 2 to 10.

[0020] The alkyl group preferably has 1 to 20 carbon atoms and may be straight, branched or cyclic. Examples of the alkyl group include methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, isobutyl group, sec-butyl group, tert-butyl group, various pentyl groups, various hexyl groups, various octyl groups, various decyl groups, various dodecyl groups, various tetradecyl groups, various hexadecyl groups, various octadecyl groups, cyclopentyl group, cyclohexyl group, and cyclooctyl group.

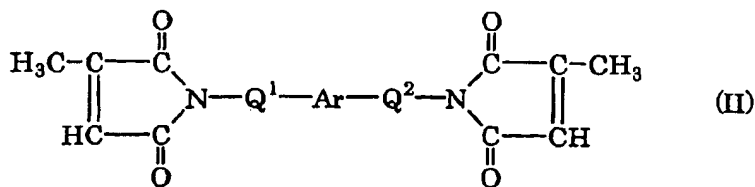
[0021] The aryl group preferably has 6 to 20 carbon atoms and may have a substituent group such as a lower alkyl group on its ring. Examples of the aryl group include phenyl group, tolyl group, xylyl group, naphthyl group, and methylnaphthyl group.

[0022] The aralkyl group preferably has 7 to 20 carbon atoms and may have a substituent group such as a lower alkyl group on its ring. Examples of the aralkyl group include benzyl group, methylbenzyl group, dimethylbenzyl group, phenethyl group, methylphenethyl group, dimethylphenethyl group, naphthylmethyl group, (methylnaphthyl)methyl group, (dimethylnaphthyl)methyl group, naphthylethyl group, (methylnaphthyl)ethyl group, and (dimethylnaphthyl)ethyl group.

[0023] Preferably, R³ to R⁶ are all aryl groups or aralkyl groups described above, and more preferably, all benzyl groups in view of prevention of heat aging and easy production. Examples of such compound include 1,2-bis(N,N'-dibenzylthiocarbamoyl-dithio)ethane, 1,3-bis(N,N'-dibenzylthiocarbamoyldithio)propane, 1,4-bis(N,N'-dibenzylthiocarbamoyldithio)butane, 1,5-bis(N,N'-dibenzylthiocarbamoyl-dithio)pentane, 1,6-bis(N,N'-dibenzylthiocarbamoyldithio)hexane, 1,7-bis(N,N'-dibenzylthiocarbamoyldithio)heptane, 1,8-bis(N,N'-dibenzylthiocarbamoyl-dithio)octane, 1,9-bis(N,N'-dibenzylthiocarbamoyldithio)nonane, and 1,10-bis(N,N'-dibenzylthiocarbamoyldithio)decane. Of these compounds, 1,6-bis(N,N'-dibenzylthiocarbamoyldithio)hexane is particularly preferable because of its effectiveness.

[0024] The improvement of the heat resistance of the rubber composition by the compound of Formula I may be attributable to its function of efficiently forming more heat-resistant monosulfide crosslinkages, while a crosslinkage between rubber polymers is broken at high temperatures.

[0025] The citraconimide compound for the component B is preferably a biscitraconimide compound such as a compound represented by the following Formula II:



and 1,3-bis(citraconimido)benzene in view of obtaining the results of the invention.

[0026] In Formula II, Ar is an arylene group, preferably a non-substituted or ring-substituted arylene group having 6 to 20 carbon atoms. The substituent for the arylene group is not specifically limited as long as it does not adversely affect the vulcanization and is stable at higher temperatures of 170 °C or higher. Examples thereof include a lower alkyl group, a lower alkoxy group, halogen, nitro group, and cyano group. Examples of the arylene group include phenylene group and naphthylene group, with phenylene group being preferred.

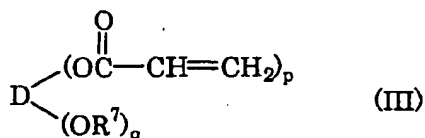
[0027] Each of Q¹ and Q² is a linear or branched alkylene group having 1 to 4 carbon atoms such as methylene group, ethylene group, propylene group, and butylene group. Q¹ and Q² may be the same as or different from each other, preferably the same in view of easy production.

[0028] Examples of the compound of Formula (II) include 1,2-bis(citraconimidomethyl)benzene, 1,3-bis(citraconimidomethyl)benzene, 1,4-bis(citraconimidomethyl)benzene, 2,3-bis(citraconimidomethyl)toluene, 2,4-bis(citraconimidomethyl)toluene, 2,5-bis(citraconimidomethyl)toluene, 2,6-bis(citraconimidomethyl)toluene, and corresponding bis(citraconimidoethyl) compounds. Of these compound, 1,3-bis(citraconimidomethyl)benzene is particularly suitable be-

cause of its effectiveness.

[0029] The improvement of the heat resistance of the rubber composition by the citraconimide compound may be attributable to its function of readily forming C-C crosslinkage by reacting with a conjugated C=C which is generated in the main chain of rubber polymers as a result of breaking of a crosslinkage at high temperatures.

[0030] The acrylate compound for the component B is preferably, in view of the effectiveness, a multifunctional ester compound derived from the reaction of a polyhydric alcohol with acrylic acid, or the reaction of a polyhydric alcohol with acrylic acid and another carboxylic acid. Examples of the multifunctional ester compound include a compound represented by the following Formula III:



wherein D is a residue derived from a (p+q) valent polyhydric alcohol by removing a hydroxyl group and R⁷ is a hydrogen or an acyl group other than acryloyl group, p is an integer from 2 to 10, q is an integer from 0 to 8, and p+q is 2 to 10. The acyl group other than acryloyl group is preferably a saturated or unsaturated aliphatic acyl group having 2 to 20 carbon atoms, although not limited thereto.

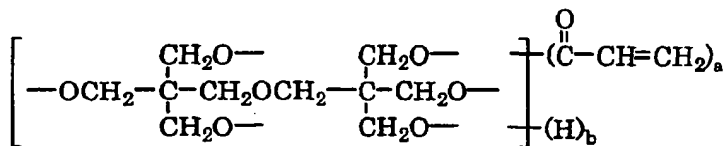
[0031] Of the compounds of Formula III, preferred are those wherein p is an integer from 3 to 6, q is an integer from 0 to 3, and p+q is 3 to 6 in view of their effectiveness.

[0032] The polyhydric alcohol for producing the acrylate compound of Formula III is represented by the following Formula IV:

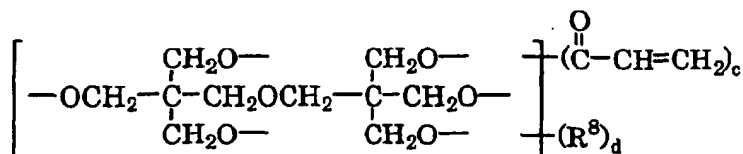


wherein D, p and q are as defined above, and preferably a three to six valent alcohol such as glycerol, trimethylolethane, trimethylolpropane, diglycerol, pentaerythritol, dipentaerythritol, and sorbitol.

[0033] Suitable compounds of Formula III in view of the effectiveness are a multifunctional ester compound having 3 to 6 acryloyl group which is derived from dipentaerythritol and acrylic acid, and an acyl-modified dipentaerythritol acrylate having 3 to 5 acryloyl group. These compounds are commercially available. For example, a compound represented by the following formula:



(a mixture of a compound wherein a = 5 and b = 1, and a compound wherein a = 6 and b = 0) is available as "KAYARAD DPHA" (trade mark, manufactured by Nippon Kayaku Co., Ltd.), and a compound represented by the following formula:



is available as "KAYARAD D-310" (trade name, manufactured by Nippon Kayaku Co., Ltd.) wherein R⁸ is an alkynoyl group, c = 5, and d = 1, and "KAYARAD D-330" (trade mark, manufactured by Nippon Kayaku Co., Ltd.) wherein R⁸ is an alkynoyl group, c = 3, and d = 3.

[0034] The improvement of the heat resistance of the rubber composition by the acrylate compound may be attributable to its function of effectively forming a C-C crosslinkage by the reaction with a conjugated C=C which is generated in the main chain of rubber polymers as a result of breaking of a crosslinkage at high temperatures.

[0035] In the production of a rubber composition using the acrylate compound, a kneading process thereof is carried out by controlling the highest temperature preferably to 140 °C or lower, more preferably 120 °C or lower. The acrylate compound may be kneaded simultaneously with a vulcanizing agent or separately.

[0036] To further improve the heat resistance of the rubber composition, it is preferred to use compounds of any combination of two or three groups selected from group 1: the compound of Formula I; group 2: the citraconimide compound; and group 3: the acrylate compound. From each group, one compound is usually selected, but, if desired, two or more compounds may be selected from any of the groups 1 to 3.

[0037] The component B comprising at least one compound as described above is compounded preferably in an amount of 0.5 to 20 parts by weight based on the rubber component as the component A. If less than 0.5 part by weight, the effect of preventing heat aging may be insufficient, thereby likely to fail to obtain a desired effect of improving the heat resistance. An amount exceeding 20 parts by weight produces little additional effect corresponding to the excessive use, and is costly disadvantageous and may cause deterioration of other properties of the resultant rubber composition. In considering the preventing effect on the heat aging, other properties of the rubber composition and production costs, the compounding amount of the component B is more preferably 0.7 to 15 parts by weight, the most preferably 1.0 to 10 parts by weight.

[0038] In addition to the component B, the rubber composition may further contain, if desired, another agent for preventing heat aging such as sodium 1,6-hexamethylenedithiosulfate dihydrate and a compound having two or more ester groups such as, but not limited thereto, an acrylate, a methacrylate, and preferably, a multifunctional ester compound derived from a reaction of a polyhydric alcohol with acrylic acid or methacrylic acid.

[0039] Examples of the polyhydric alcohol include alkylene glycols such as ethylene glycol, propylene glycol, butylene glycol, pentanediol, and hexanediol; polymers of the alkylene glycol; methylol-functionalized alkylene glycols; pentaerythritol and its derivatives; and polyhydric alcohol-alkylene oxide adducts; and polyesters or oligoesters having two or more alcoholic hydroxyl groups, with the methylol-functionalized alkylene glycols being particularly preferred.

[0040] Examples of the compound having two or more ester groups include 1,3-butylene glycol diacrylate, 1,5-pentanediol diacrylate, neopentyl glycol diacrylate, 1,6-hexanediol diacrylate, diethylene glycol diacrylate, triethylene glycol diacrylate, tetraethylene glycol diacrylate, polyethylene glycol diacrylate, polypropylene glycol diacrylate, pentaerythritol triacrylate, trimethylolpropane triacrylate, pentaerythritol tetracrylate, dipentaerythritol hexacrylate, dipentaerythritol pentacrylate, oligoester polyacrylate, dipropylene glycol dimethacrylate, trimethylolethane trimethacrylate, trimethylolpropane trimethacrylate, dipentaerythritol pentamethacrylate, and dipentaerythritol trimethacrylate, with dipentaerythritol methacrylate, dipentaerythritol trimethacrylate and trimethylolpropane methacrylate being particularly preferred.

[0041] Sodium 1,6-hexamethylenedithiosulfate dihydrate mentioned above prevents the breaking of a crosslinkage between the polymer chains constituting the rubber component. The compound having two or more ester groups is presumed to act as follows. When the temperature of the rubber composition is elevated to 170 °C or higher, the crosslinkages and polymer chains begin to be broken, thereby degrading the rubber composition. However, simultaneously with the breaking, the compound promotes the formation of carbon-to-carbon crosslinkages to prevent the loss of elasticity, thereby avoiding the heat generation of the rubber composition even at higher temperatures.

[0042] The rubber composition may further contain a reinforcing filler known in the rubber art without limitation. Preferred are carbon black, silica, and aluminum hydroxide. Silica and aluminum hydroxide can further reinforce the rubber when used with a coupling agent.

[0043] In addition to the above components, the rubber composition may further contain an additive known in the rubber art, for example, a vulcanizing agent such as sulfurs and peroxides, a vulcanization accelerator, an antioxidant, a softening agent, and an inorganic filler. The rubber composition may be made into a composite with particle, fiber and cloth of various materials.

[0044] The rubber composition of the present invention is excellent in the heat resistance and is suitable particularly for use in a tire bead filler rubber and a reinforcing rubber for a tire sidewall.

[0045] The heat resistance of the rubber composition is evaluated by the following method.

[0046] First, the dynamic storage elastic modulus of a vulcanized rubber composition is measured while raising the temperature, and draw a graph of the measured dynamic storage elastic modulus against the temperature. From the resultant curve, the peak value of the dynamic storage elastic modulus and its temperature, the bottom value of the dynamic storage elastic modulus and its temperature, and the dynamic storage elastic modulus at 250 °C are read. The ratio, bottom dynamic storage elastic modulus/peak dynamic storage elastic modulus, is calculated from the obtained values. The larger the ratio and the value of the dynamic storage elastic modulus at 250 °C, the higher the heat resistance.

[0047] Next, the pneumatic tire of the present invention will be described with reference to the attached drawing.

[0048] Fig. 1 is a partial cross-sectional schematic view of a pneumatic tire of the present invention. A pneumatic

tire 1 has a pair of right and left ring shaped bead cores 4, a bead filler 5 provided at radially outward of each of the bead cores 4, a carcass layer 2 comprising at least one ply which comprises a plurality of parallel cords embedded in a coating rubber, a belt layer 3 provided at radially outward of the carcass layer 2, a tread portion 8 provided at radially outward of the belt layer 3, a pair of sidewall portions 6 provided at both right and left lateral edges of the tread portion 8, and a reinforcing rubber layer 7 at the sidewall portions 6.

[0049] The carcass layer 2 has a turned-up carcass ply 2a and a down carcass ply 2b. Both ends of the turned-up carcass ply 2a are turned-up around the pair of the bead cores 4 to form a pair of turnup ends. The bead filler 5 is located between the turned-up carcass ply 2a and its turnup end. The down carcass ply 2b is disposed between the sidewall portion 6 and the turnup end of the turned-up carcass ply 2a. The reinforcing rubber layer 7 is disposed inside the turned-up carcass ply 2a at the sidewall portion. The reinforcing rubber layer 7 for reinforcing the sidewall portion 6 may be a composite of a rubber with organic fibers or inorganic particles. The cross-sectional shape of the reinforcing rubber layer 7 is not specifically limited as far as the function of reinforcing the sidewall portion is attained. Air, nitrogen gas, etc. are used for inflating tires.

[0050] In the pneumatic tire of the present invention, either or both of the bead filler 5 and the reinforcing rubber layer 7 are made of the rubber composition of the present invention described above. Since the rubber composition of the invention maintains its elasticity within the intended level at low temperatures, the loss of ride performance and unacceptable noise levels due to the increase of elasticity do not substantially occur during normal operation of tire. Even when its temperature is elevated to 170 °C or higher by drastic change of shape due to puncture of tires, the rubber composition is resistant to the lowering of its elasticity. Therefore, the heat generation at high temperatures is prevented, thereby enhancing the durability of tires.

[0051] Therefore, with the use of a bead core or a rubber layer for reinforcing the sidewall portions made of the rubber composition of the present invention, the durability of pneumatic tires, particularly during the tire operations under the runflat conditions, can be dramatically improved, and the drive range in the runflat conditions can be remarkably extended.

[0052] The present invention will be described in more detail with reference to the following examples. However, it should be noted that the following examples are illustrative and not intended to limit the scope of the present invention thereto.

[0053] The properties of the rubber compositions and the runflat durability of tires were measured by the following methods.

(1) Dynamic storage elastic modulus (E') and other properties of rubber composition

[0054] A sample of 5 mm wide and 40 mm long was cut out from a slab sheet with 2 mm thickness which was prepared by vulcanizing a rubber composition at 160 °C for 12 min.

[0055] The dynamic storage elastic modulus of the sample was measured by using a spectrometer manufactured by Ueshima Seisakusho Co., Ltd. under the following conditions:

Chuck interval: 10 mm

Initial strain: 200 μ m

Dynamic strain: 1%

Frequency: 52 Hz

while raising the temperature from 25 °C to 250 °C at a rate of 3 °C/min. The measured dynamic storage elastic modulus was plotted against the temperature. From the resultant graph, the peak dynamic storage elastic modulus and its temperature, the bottom dynamic storage elastic modulus and its temperature, and the dynamic storage elastic modulus at 250 °C were read. From the obtained values, the ratio of bottom dynamic storage elastic modulus/peak dynamic storage elastic modulus was calculated.

[0056] In Examples 1 to 19, (bottom dynamic storage elastic modulus - peak dynamic storage elastic modulus)/(bottom temperature - peak temperature) (hereinafter referred to as "slope") was calculated.

[0057] Each of the above values is expressed by index numbers taking the value of Comparative Example 1, 2 or 3 as 100. The larger the index for the bottom dynamic storage elastic modulus/peak dynamic storage elastic modulus ratio, or larger the index for the dynamic storage elastic modulus at 250 °C, the higher the heat resistance. And, the smaller the index for the slope, the higher the heat resistance.

(2) Runflat durability of tires

[0058] A tire was mounted on a rim under atmospheric pressure, and then, inflated with air to an internal pressure of 200 kPa. After allowed to stand at 38 °C for 24 h, the core of a valve was pulled out to deflate the tire to atmospheric

pressure. The tire thus treated was subjected to a drum driving test at 38 °C at a driving speed of 89 km/h under a load of 5.6 kN (570 kg). The driving distance before the tire failure occurred is employed as the runflat durability and expressed by an index number taking the result of Comparative Example 1, 2 or 3 as 100. The larger the index, the better the runflat durability.

EXAMPLES 1 to 19

[0059] As the component B represented by Formula I, Compounds A to E shown in Table 1 were used.

[0060] A rubber composition was prepared by compounding 100 parts by weight of a rubber component consisting 30.0 parts by weight of a natural rubber and 70.0 parts by weight of butadiene rubber "BR01" (trade mark of JSR Corporation.) with 60.0 parts by weight of carbon black FEF, 3.0 parts by weight of a spindle oil, 5.0 parts by weight of zinc white, 1.0 part by weight of stearic acid, 2.0 parts by weight of antioxidant "Nocrac 6C" (trade mark of Ouchi Shinko Chemical Industrial Co., Ltd.; N-phenyl-N'-(1,3-dimethylbutyl)-p-phenylenediamine), 2.5 parts by weight of a vulcanization accelerator "Nocceler-NS" (trade mark of Ouchi Shinko Chemical Industrial Co., Ltd.; N-tert-butyl-2-benzothiazolylsulphenamide), a compound for the component B of a kind and amount shown in Table 1, and 5.0 parts by weight of sulfur. The properties of the vulcanized product thereof are shown in Table 1.

[0061] According to a known method, a passenger radial tire of size 225/60R16 was produced, which has a bead filler and/or a reinforcing layer for sidewall portion (side reinforcing rubber) made of the above rubber composition. The result of the runflat durability test of the tire is shown in Table 1.

COMPARATIVE EXAMPLE 1

[0062] A rubber composition shown in Table 1 was prepared in the same manner as in Example 1 except for omitting the use of the component B and changing the amount of sulfur to 6 parts by weight. The properties of the vulcanized product thereof are shown in Table 1.

[0063] In the same manner as in Example 1, a tire having a reinforcing layer for sidewall portion and a bead filler both made of the above rubber composition was produced. The result of the runflat durability test of the tire is shown in Table 1.

Table 1-1

	Com. Ex. 1	Examples						
		1	2	3	4	5	6	7
Rubber composition	C-1	E-1	E-2	E-3	E-4	E-5	E-6	E-7
Formulation								
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B								
compound A of formula I	-	0.4	0.5	1.0	3.0	5.0	10.0	0.4
sulfur	6.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Properties of vulcanized rubber composition (index)								
peak temperature	100	100	101	103	106	110	116	100
peak E'	100	100	103	105	110	116	120	100
bottom temperature	100	101	101	102	104	106	107	101
bottom E'	100	101	105	113	123	134	143	101
bottom E'/peak E'	100	101	103	107	113	116	118	101
slope	100	97	93	86	71	66	63	97
Tire								

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Table 1-1 (continued)

	Com. Ex. 1	Examples						
		1	2	3	4	5	6	7
constituting composition								
side reinforcing rubber	C-1	E-1	E-2	E-3	E-4	E-5	E-6	C-1
bead filler rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1	E-7
runflat durability (index)	100	102	105	113	124	135	145	100

Table 1-2

	Examples							
	8	9	10	11	12	13	14	15
Rubber composition	E-8	E-9	E-10	E-11	E-12	E-13	E-14	E-15
Formulation								
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B								
compound A of formula I	0.5	1.0	3.0	5.0	10.0	1.0	3.0	5.0
sulfur	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Properties of vulcanized rubber composition (index)								
peak temperature	101	103	106	110	116	103	106	110
peak E'	103	105	110	116	120	106	110	116
bottom temperature	101	102	104	106	107	102	104	106
bottom E'	105	113	123	134	143	113	123	134
bottom E'/peak E'	103	107	113	116	118	107	113	116
slope	93	86	71	66	63	86	71	66
Tire								
constituting composition								
side reinforcing rubber	C-1	C-1	C-1	C-1	C-1	E-13	E-14	E-15
bead filler rubber	E-8	E-9	E-10	E-11	E-12	E-13	E-14	E-15
runflat durability (index)	102	105	110	116	121	122	141	160

Table 1-3

	Examples			
	16	17	18	19
Rubber composition	E-16	E-17	E-18	E-19
Formulation				
natural rubber	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0

Table 1-3 (continued)

		Examples			
		16	17	18	19
5	stearic acid	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0
	vulcanization accelerator	2.5	2.5	2.5	2.5
	component B				
10	compound B of formula I	3.0	-	-	-
	compound C of formula I	-	3.0	-	-
	compound D of formula I	-	-	3.0	-
	compound E of formula I	-	-	-	3.0
	sulfur	5.0	5.0	5.0	5.0
15	Properties of vulcanized rubber composition (index)				
	peak temperature	108	107	106	105
	peak E'	112	109	110	110
	bottom temperature	105	104	104	103
20	bottom E'	127	124	122	121
	bottom E'/peak E'	114	113	111	110
	slope	69	70	74	80
	Tire				
	constituting composition side reinforcing rubber	E-16	E-17	E-18	E-19
25	bead filler rubber	E-16	E-17	E-18	E-19
	runflat durability (index)	144	142	139	137
<p>Note: E' = dynamic storage elastic modulus Com. Ex. = Comparative Example (1) Compound of Formula I for component B 1) Compound A: 1,6-bis(N,N'-dibenzylthiocarbamoyldithio)hexane (VULCUREN TRIAL PRODUCT KA9188 of Bayer Akiengesellschaft) 2) Compound B: 1,6-bis(N,N'-dimethylthiocarbamoyldithio)hexane (trial product) 3) Compound C: 1,6-bis(N,N'-diethylthiocarbamoyldithio)hexane (trial product) 35 4) Compound D: 1,6-bis(N,N'-di(2-ethylhexyl)thiocarbamoyldithio)-hexane (trial product) 5) Compound E: 1,6-bis(benzothiazolyldithio)hexane (trial product) (2) Constituting composition: Each tire member was made of the respective rubber composition shown in Table 1.</p>					

40 **[0064]** As seen from Table 1, the heat resistance was improved in the rubber compositions containing the compound of Formula I for the component B. In addition, the pneumatic tires having a bead filler or a reinforcing layer for sidewall made of the rubber composition of the invention is good in the runflat durability. In particular, the runflat durability is excellent when both the bead filler and the reinforcing layer for sidewall are made of the rubber composition of the invention.

45 EXAMPLES 20 to 34

[0065] As the citraconimide compound for the component B, 1,3-bis(citraconimidomethyl)benzene was used.

50 **[0066]** Each rubber composition was prepared in the same manner as in Example 1 except for using, in place of 1,6-bis(N,N'-dibenzylthiocarbamoyldithio)hexane, 1,3-bis(citraconimidomethyl)benzene in respective amount shown in Table 2, and compounding sulfur in an amount of 6.0 parts by weight. The properties of the vulcanized product thereof are shown in Table 2.

55 **[0067]** According to a known method, each passenger radial tire of size 225/60R16 was produced, which has a reinforcing layer for sidewall portion and a bead filler each made of the respective rubber composition. The result of the runflat durability test of each tire is shown in Table 2.

Table 2-1

	Com. Ex. 1	Examples						
		20	21	22	23	24	25	26
Rubber composition	C-1	E-20	E-21	E-22	E-23	E-24	E-25	E-26
Formulation								
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B								
citraconimide compound	-	0.4	0.5	1.0	3.0	5.0	10.0	0.4
sulfur	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Properties of vulcanized rubber composition (index)								
peak temperature	100	100	100	100	101	102	103	100
peak E'	100	100	100	100	101	103	105	100
bottom temperature	100	99	99	98	95	93	90	99
bottom E'	100	101	102	106	114	126	135	101
bottom E'/peak E'	100	101	103	106	113	123	128	101
E' at 250 °C	100	102	106	112	120	137	146	102
Tire								
constituting composition								
side reinforcing rubber	C-1	E-20	E-21	E-22	E-23	E-24	E-25	C-1
bead filler rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1	E-26
runflat durability (index)	100	101	104	107	116	132	143	100

Table 2-2

			Examples					
	27	28	29	30	31	32	33	34
Rubber composition	E-27	E-28	E-29	E-30	E-31	E-32	E-33	E-34
Formulation								
natural rubber	30	30	30	30	30	30	30	30
butadiene rubber	70	70	70	70	70	70	70	70
carbon black	60	60	60	60	60	60	60	60
softening agent	3	3	3	3	3	3	3	3
zinc white	5	5	5	5	5	5	5	5
stearic acid	1	1	1	1	1	1	1	1
antioxidant	2	2	2	2	2	2	2	2
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B								
citraconimide compound	0.5	1	3	5	10	1	3	5
sulfur	6	6	6	6	6	6	6	6
Properties of vulcanized rubber composition (index)								
peak temperature	100	100	101	102	103	100	101	102

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Table 2-2 (continued)

		Examples							
		27	28	29	30	31	32	33	34
Tire	peak E'	100	100	101	103	105	100	101	103
	bottom temperature	99	98	95	93	90	98	95	93
	bottom E'	102	106	114	126	135	106	114	126
	bottom E'/peak E'	103	106	113	123	128	106	113	123
	E' at 250 °C	106	112	120	137	146	112	120	137
	constituting composition								
	side reinforcing rubber	C-1	C-1	C-1	C-1	C-1	E-32	E-33	E-34
	bead filler rubber	E-27	E-28	E-29	E-30	E-31	E-32	E-33	E-34
	runflat durability (index)	102	103	106	111	115	115	132	158
Note: E' = dynamic storage elastic modulus Com. Ex. = Comparative Example (1) Component B (citraconimide compound) 1,3-bis(citraconimidomethyl)benzene (PERKALINK 900, trade mark of Flexis Co. Ltd.) (2) Constituting composition: Each tire member was made of the respective rubber composition shown in Table 2.									

EXAMPLES 35 to 53

[0068] As the citraconimide compound for the component B, 1,3-bis(citraconimido)benzene was used. In Examples 52 and 53, the compound of Formula I used above or an acrylate compound was combinedly used.

[0069] Each rubber composition was prepared in the same manner as in Example 20 except for using, as the component B, respective compound in respective amount shown in Table 3, and using sulfur in an amount of 5.0 parts by weight. The properties of the vulcanized product thereof are shown in Table 3.

COMPARATIVE EXAMPLE 2

[0070] A rubber composition shown in Table 3 was prepared in the same manner as in Example 35 except for omitting the use of the component B. The properties of the vulcanized product thereof are shown in Table 3.

[0071] Then, each tire was produced in the same manner as in Example 35 while forming the reinforcing layer for sidewall and the bead filler by respective rubber composition. The result of the runflat durability test of each tire is shown in Table 3.

Table 3-1

	Com. Ex. 1	Examples					
		35	36	37	38	39	40
Rubber composition	C-2	E-35	E-36	E-37	E-38	E-39	E-40
Formulation							
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B							
1.3-bis(citraconimido)- benzene	-	0.2	0.3	0.5	1.0	3.0	5.0
compound A of formula I	-	-	-	-	-	-	-

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Table 3-1 (continued)

	Com. Ex. 1	Examples					
		35	36	37	38	39	40
5	compound B of formula I	-	-	-	-	-	-
	acrylate compound A	-	-	-	-	-	-
	acrylate compound B	-	-	-	-	-	-
	sulfur	5.0	5.0	5.0	5.0	5.0	5.0
10	Properties of vulcanized rubber composition (index)						
	peak temperature	100	100	100	101	101	101
	peak E'	100	100	101	102	103	105
	bottom temperature	100	99	98	96	95	94
	bottom E'	100	101	103	106	110	118
15	bottom E'/peak E'	100	101	102	104	107	112
	E' at 250 °C	100	103	106	110	116	127
	Tire						
	constituting composition						
20	side reinforcing rubber	C-2	E-35	E-36	E-37	E-38	E-39
	bead filler rubber	C-2	C-2	C-2	C-2	C-2	C-2
	runflat durability (index)	100	101	103	106	110	122
							133

Table 3-2

		Examples					
		41	42	43	44	45	46
25							
	Rubber composition	E-41	E-42	E-43	E-44	E-45	E-46
30	Formulation						E-47
	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0
35	softening agent	3.0	3.0	3.0	3.0	3.0	3.0
	zinc white	5.0	5.0	5.0	5.0	5.0	5.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0
	vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5
40	component B						
	1.3-bis(citraconimido)- benzene	10.0	0.2	0.3	0.5	1.0	3.0
	compound A of formula I	-	-	-	-	-	-
	compound B of formula I	-	-	-	-	-	-
45	acrylate compound A	-	-	-	-	-	-
	acrylate compound B	-	-	-	-	-	-
	sulfur	5.0	5.0	5.0	5.0	5.0	5.0
	Properties of vulcanized rubber composition (index)						
	peak temperature	101	100	100	100	101	101
50	peak E'	110	100	101	102	103	105
	bottom temperature	90	99	98	96	95	94
	bottom E'	143	101	103	106	110	118
	bottom E'/peak E'	130	101	102	104	107	112
55	E' at 250 °C	155	103	106	110	116	127
	Tire						
	constituting composition						

Table 3-2 (continued)

	Examples						
	41	42	43	44	45	46	47
side reinforcing rubber	E-41	C-2	C-2	C-2	C-2	C-2	C-2
bead filler rubber	C-2	E-42	E-43	E-44	E-45	E-46	E-47
runflat durability (index)	148	100	102	104	106	110	116

Table 3-3

	Examples					
	48	49	50	51	52	53
Rubber composition	E-48	E-49	E-50	E-51	E-52	E-53
Formulation						
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5
component B						
1,3-bis(citraconimido)-benzene	10.0	1.0	3.0	5.0	3.0	3.0
compound A of formula I	-	-	-	-	3.0	-
compound B of formula I	-	-	-	-	-	3.0
acrylate compound A	-	-	-	-	3.0	-
acrylate compound B	-	-	-	-	-	3.0
sulfur	5.0	5.0	5.0	5.0	5.0	5.0
Properties of vulcanized rubber composition (index)						
peak temperature	101	101	101	101	107	108
peak E'	110	103	105	107	119	123
bottom temperature	90	95	94	92	93	94
bottom E'	143	110	118	130	155	163
bottom E'/peak E'	130	107	112	121	130	133
E' at 250 °C	155	116	127	141	160	168
Tire						
constituting composition						
side reinforcing rubber	C-2	E-49	E-50	E-51	E-52	E-53
bead filler rubber	E-48	E-49	E-50	E-51	E-52	E-53
runflat durability (index)	120	121	138	158	201	209
Note: Com. Ex. = Comparative Example						

[0072] As seen from Tables 2 and 3, the heat resistance was improved in the rubber compositions containing the citraconimide compound as the component B. In addition, the pneumatic tires having a bead filler or a reinforcing layer for sidewall made of the rubber composition of the invention is good in the runflat durability. In particular, the runflat durability is excellent when both the bead filler and the reinforcing layer for sidewall are made of the rubber composition of the invention.

EXAMPLES 54 to 72

[0073] As the component B, the acrylate compounds A to C shown in Table 4 were used.

[0074] A rubber component (100 parts by weight) consisting of 30.0 parts by weight of a natural rubber and 70.0 parts by weight of butadiene rubber "BR01" (trade mark of JSR Corporation.) was kneaded at a maximum temperature of 100 °C with 60.0 parts by weight of carbon black FEF, 3.0 parts by weight of a spindle oil, 5.0 parts by weight of zinc white, 1.0 part by weight of stearic acid, and 2.0 parts by weight of an antioxidant "Nocrac 6C" (trade mark of Ouchi Shinko Chemical Industrial Co., Ltd.; N-phenyl-N'-(1,3-dimethylbutyl)-p-phenylenediamine). The resultant product was further kneaded with 2.5 parts by weight of a vulcanization accelerator "Nocceler-NS" (trade mark of Ouchi Shinko Chemical Industrial Co., Ltd.; N-tert-butyl-2-benzothiazolylsulphenamide), the component B of a kind in an amount shown in Table 4, and 6.0 parts by weight of sulfur at a maximum temperature of 100 °C, thereby preparing a rubber composition. The component B was added in a 50 wt % supported form on silica (Nipsil AQ available from Nippon Silica Industrial Co., Ltd.). The properties of the vulcanized product thereof are shown in Table 4.

[0075] According to a known method, a passenger radial tire of size 225/60R16 was produced, which has a bead filler and/or a reinforcing layer for sidewall portion (side reinforcing rubber) made of each rubber composition. The result of the runflat durability test of each tire is shown in Table 4.

COMPARATIVE EXAMPLE 3

[0076] In the same manner as in Example 54 except for omitting the use of the component B, a rubber composition shown in Table 4 was prepared. The properties of the vulcanized product thereof are shown Table 4.

[0077] In the same manner as in Example 54, a tire having a reinforcing layer for sidewall portion and a bead filler both made of the above rubber composition was produced. The result of the runflat durability test of the tire is shown in Table 4.

Table 4-1

	Com. Ex. 3	Examples							
		54	55	56	57	58	59	60	61
Rubber composition	C-3	E-54	E-55	E-56	E-57	E-58	E-59	E-60	E-61
Formulation									
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B									
acrylate compound A	-	0.4	0.5	1.0	3.0	5.0	10.0	20.0	0.4
sulfur	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Properties of vulcanized rubber composition (index)									
peak temperature	100	100	100	100	100	102	103	103	100
peak E'	100	102	104	107	111	114	118	123	102
bottom temperature	100	100	99	99	98	95	92	90	100
bottom E'	100	101	105	114	121	131	140	147	101
bottom E'/peak E'	100	100	102	106	109	115	119	120	100
E' at 250 °C	100	103	108	117	127	140	149	155	103
Tire									
constituting composition									
side reinforcing rubber	C-3	E-54	E-55	E-56	E-57	E-58	E-59	E-60	C-3
bead filler rubber	C-3	C-3	C-3	C-3	C-3	C-3	C-3	C-3	E-61
runflat durability (index)	100	102	106	114	123	134	142	149	100

Table 4-2

	Examples								
	62	63	64	65	66	67	68	69	70
Rubber composition	E-62	E-63	E-64	E-65	E-66	E-67	E-68	E-69	E-70
Formulation									
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
component B									
acrylate compound A	0.5	1.0	3.0	5.0	10.0	20.0	1.0	3.0	5.0
sulfur	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Properties of vulcanized rubber composition (index)									
peak temperature	100	100	100	102	103	103	100	100	102
peak E'	104	107	111	114	118	123	107	111	114
bottom temperature	99	99	98	95	92	90	99	98	95
bottom E'	105	114	121	131	140	147	114	121	131
bottom E'/peak E'	102	106	109	115	119	120	106	109	115
E' at 250 °C	108	117	127	140	149	155	117	127	140
Tire									
constituting composition									
side reinforcing rubber	C-3	C-3	C-3	C-3	C-3	C-3	E-68	E-69	E-70
bead filler rubber	E-62	E-63	E-64	E-65	E-66	E-67	E-68	E-69	E-70
runflat durability (index)	103	107	111	116	120	124	125	140	159

Table 4-3

	Examples	
	71	72
Rubber composition	E-71	E-72
Formulation		
natural rubber	30.0	30.0
butadiene rubber	70.0	70.0
carbon black	60.0	60.0
softening agent	3.0	3.0
zinc white	5.0	5.0
stearic acid	1.0	1.0
antioxidant	2.0	2.0
vulcanization accelerator	2.5	2.5
component B		
acrylate compound B	3.0	-
acrylate compound C	-	3.0
sulfur	6.0	6.0
Properties of vulcanized rubber composition (index)		
peak temperature	100	100

Table 4-3 (continued)

		Examples	
		71	72
5	peak E'	113	109
	bottom temperature	97	98
	bottom E'	126	118
	bottom E'/peak E'	111	108
10	E' at 250 °C	130	124
	Tire		
	constituting composition		
	side reinforcing rubber	E-71	E-72
	bead filler rubber	E-71	E-72
15	runflat durability (index)	142	137

Note: E' = dynamic storage elastic modulus

Com. Ex. = Comparative Example

(1) Component B (acrylate compound)

1) Acrylate compound A: "KAYARAD D310" (trade mark of Nippon Kayaku Co., Ltd.)

2) Acrylate compound B: "KAYARAD DPHA" (trade mark of Nippon Kayaku Co., Ltd.)

3) Acrylate compound C: "KAYARAD D330" (trade mark of Nippon Kayaku Co., Ltd.)

(2) Constituting composition: Each tire member was made of the respective rubber composition shown in Table 4.

[0078] As seen from Table 4, the heat resistance was improved in the rubber compositions containing an acrylate compound as the component B. In addition, the pneumatic tires having a bead filler or a reinforcing layer for sidewall made of the rubber composition of the invention is good in the runflat durability. In particular, the runflat durability is excellent when both the bead filler and the reinforcing layer for sidewall are made of the rubber composition of the invention.

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[0079] Each rubber composition was prepared in the same manner as in Example 1 except for using, as the component B, two or three kinds of compounds in respective amounts as shown in Table 5, and compounding 5.0 or 6.0 parts by weight of sulfur. The properties of the vulcanized product thereof are shown in Table 5.

[0080] According to a known method, a passenger radial tire of size 225/60R16 was produced, which has a reinforcing layer for sidewall portion and a bead filler both made of each rubber composition. The result of the runflat durability test of each tire is shown in Table 5.

[0081] For comparison, the results of Examples 1, 20 and 54 (Table 5-1) and Examples 7, 26 and 61 (Table 5-5), in which only one compound was used as the component B, are recompiled.

Table 5-1

	Com. Ex. 1	Examples						
		1	20	54	73	74	75	76
45	Rubber composition	C-1	E-1	E-20	E-54	E-73	E-74	E-75
	Formulation							
	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0
50	softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0
55	vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	compound A of formula I	-	0.4	-	0.4	0.4	-	0.1
	citraconimide compound A	-	-	0.4	-	0.1	-	0.4

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Table 5-1 (continued)

	Com. Ex. 1	Examples						
		1	20	54	73	74	75	76
5	acrylate compound A	-	-	0.4	-	0.1	0.1	-
	sulfur	6.0	5.0	6.0	5.0	5.0	6.0	6.0
	Properties of vulcanized rubber composition (index)							
10	peak temperature	100	100	100	100	100	100	101
	peak E'	100	100	100	102	100	101	102
	bottom temperature	100	101	99	100	100	100	99
	bottom E'	100	101	101	101	101	103	103
	bottom E'/peak E'	100	101	101	100	102	102	102
15	E' at 250 °C	100	103	102	103	104	105	104
	Tire							
	constituting composition							
	side reinforcing rubber	C-1	E-1	E-20	E-54	E-73	E-74	E-75
20	bead filler rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1
	runflat durability (index)	100	102	101	102	104	105	104

Table 5-2

		Examples						
		77	78	79	80	81	82	83
25	Rubber composition	E-77	E-78	E-79	E-80	E-81	E-82	E-83
	Formulation							
30	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0
	softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0
35	zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5
40	compound A of formula I	0.1	-	0.25	0.25	-	0.5	0.5
	citraconimide compound A	-	0.1	0.25	-	0.25	0.5	-
	acrylate compound A	0.4	0.4	-	0.25	0.25	-	0.5
	sulfur	6.0	6.0	5.0	5.0	6.0	5.0	5.0
	Properties of vulcanized rubber composition (index)							
45	peak temperature	101	100	101	101	100	102	102
	peak E'	104	104	102	104	102	103	107
	bottom temperature	100	99	100	100	99	100	101
	bottom E'	104	104	104	105	104	110	114
50	bottom E'/peak E'	101	101	103	102	103	106	106
	E' at 250 °C	106	105	106	107	107	110	115
	Tire							
	constituting composition							
55	side reinforcing rubber	E-77	E-78	E-79	E-80	E-81	E-82	E-83
	bead filler rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1
	runflat durability (index)	105	104	105	106	105	110	114

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Table 5-3

	Examples								
	85	86	87	88	89	90	91	92	93
Rubber composition	E-85	E-86	E-87	E-88E	E-89	E-90	E-91	E-92	E-93
Formulation									
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
compound A of formula I	1.0	1.0	-	1.5	1.5	-	3.0	3.0	-
citraconimide compound A	1.0	-	1.0	1.5	-	1.5	3.0	-	3.0
acrylate compound A	-	1.0	1.0	-	1.5	1.5	-	3.0	3.0
sulfur	5.0	5.0	6.0	5.0	5.0	6.0	5.0	5.0	6.0
Properties of vulcanized rubber composition (index)									
peak temperature	103	102	100	104	103	101	107	107	102
peak E'	104	109	105	106	111	107	110	116	109
bottom temperature	100	101	98	100	101	97	99	100	93
bottom E'	114	118	114	119	122	118	132	134	130
bottom E'/peak E'	109	108	109	113	111	111	120	116	120
E' at 250 °C	114	117	119	117	121	124	133	134	140
Tire									
constituting composition									
side reinforcing rubber	E-85	E-86	E-87	E-88E	E-89	E-90	E-91	E-92	E-93
bead filler rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
runflat durability (index)	115	119	115	120	124	120	135	136	135

Table 5-4

	Examples								
	94	95	96	97	98	99	100	101	102
Rubber composition	E-94	E-95	E-96	E-97	E-98	E-99	E-100	E-101	E-102
Formulation									
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
compound A of formula I	5.0	5.0	-	1.0	1.5	3.0	3.0	5.0	5.0
citraconimide compound A	5.0	-	5.0	1.0	1.5	3.0	3.0	5.0	5.0

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Table 5-4 (continued)

		Examples								
		94	95	96	97	98	99	100	101	102
5	acrylate compound A	-	5.0	5.0	1.0	1.5	3.0	5.0	5.0	10.0
	sulfur	5.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0
	Properties of vulcanized rubber composition (index)									
	peak temperature	110	110	103	103	104	108	108	111	111
	peak E'	113	120	112	109	111	118	120	123	124
	bottom temperature	99	100	91	99	97	94	91	89	87
	bottom E'	139	142	138	124	130	152	156	164	167
	bottom E'/peak E'	123	119	124	113	118	129	131	134	135
	E' at 250 °C	140	142	148	125	132	158	162	171	173
	Tire									
10	constituting composition									
	side reinforcing rubber	E-94	E-95	E-96	E-97	E-98	E-99	E-100	E-101	E-102
	bead filler rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
	runflat durability (index)	144	147	146	125	133	157	164	176	178

Table 5-5

		Examples							
		7	26	61	103	104	105	106	107
Rubber composition		E-7	E-26	E-61	E-103	E-104	E-105	E-106	E-107
Formulation									
	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
	softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	vulcanization accelerator	2.5	2.5	2.6	2.5	2.5	2.5	2.5	2.5
	compound A of formula I	0.4	-	-	0.4	0.4	-	0.1	0.1
	citraconimide compound A	-	0.4	-	0.1	-	0.4	0.4	-
	acrylate compound A	-	-	0.4	-	0.1	0.1	-	0.4
	sulfur	5.0	6.0	6.0	5.0	5.0	6.0	6.0	6.0
Properties of vulcanized rubber composition (index)									
	peak temperature	100	100	100	100	100	100	101	101
	peak E'	100	100	102	100	101	103	102	104
	bottom temperature	101	99	100	100	100	98	99	100
	bottom E'	101	101	101	101	103	103	103	104
	bottom E'/peak E'	101	101	100	102	102	101	102	101
	E' at 250 °C	103	102	103	104	105	105	104	106
Tire									
	constituting composition								
	side reinforcing rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
	bead filler rubber	E-7	E-26	E-61	E-103	E-104	E-105	E-106	E-107

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Table 5-5 (continued)

	Examples							
	7	26	61	103	104	105	106	107
runflat durability (index)	100	100	100	101	102	101	101	102

Table 5-6

10		Examples						
		108	109	110	111	112	113	114
	Rubber composition	E-108	E-109	E-110	E-111	E-112	E-113	E-114
	Formulation							
15	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0
	softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0
20	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	compound A of formula I	-	0.25	0.25	-	0.5	0.5	-
25	citraconimide compound A	0.1	0.25	-	0.25	0.5	-	0.5
	acrylate compound A	0.4	-	0.25	0.25	-	0.5	0.5
	sulfur	6.0	5.0	5.0	6.0	5.0	5.0	6.0
	Properties of vulcanized rubber composition (index)							
	peak temperature	100	101	101	100	102	102	100
30	peak E'	104	102	104	102	103	107	104
	bottom temperature	99	100	100	99	100	101	99
	bottom E'	104	104	105	104	110	114	110
	bottom E'/peak E'	101	103	102	103	106	106	106
35	E' at 250 °C	105	106	107	107	110	115	115
	Tire							
	constituting composition							
	side reinforcing rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1
	bead filler rubber	E-108	E-109	E-110	E-111	E-112	E-113	E-114
40	runflat durability (index)	102	102	103	102	104	106	105

Table 5-7

45		Examples								
		115	116	117	118	119	120	121	122	123
50	Rubber composition	E-115	E11 6	E-117	E-118	E-119	E-120	E-121	E-122	E-123
	Formulation									
	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
	softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	55 zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

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Table 5-7 (continued)

		Examples								
		115	116	117	118	119	120	121	122	123
5	vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	compound A of formula I	1.0	1.0	-	1.5	1.5	-	3.0	3.0	-
	citraconimide compound A	1.0	-	1.0	1.5	-	1.5	3.0	-	3.0
	acrylate compound A	-	1.0	1.0	-	1.5	1.5	-	3.0	3.0
10	sulfur	5.0	5.0	6.0	5.0	5.0	6.0	5.0	5.0	6.0
	Properties of vulcanized rubber composition (index)									
	peak temperature	103	102	100	104	103	101	107	107	102
	peakE'	104	109	105	106	111	107	110	116	109
15	bottom temperature	100	101	98	100	101	97	99	100	93
	bottom E'	114	118	114	119	122	118	132	134	130
	bottom E'/peak E'	109	108	109	113	111	111	120	116	120
	E' at 250 °C	114	117	119	117	121	124	133	134	140
20	Tire									
	constituting composition									
	side reinforcing rubber	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
	bead filler rubber	E-	E11	E-	E-	E-	E-	E-	E-	E-
		115	6	117	118	119	120	121	122	123
25	runflat durability (index)	106	108	107	108	111	109	114	117	114

Table 5-8

30		Examples								
		124	125	126	127	128	129	130	131	132
	Rubber composition	E-124	E-125	E-126	E-127	E-128	E-129	E-130	E-131	E-132
35	Formulation									
	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
	softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
40	zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	vulcanization accelerator	2.5	2.5	2.5	2.5	2.6	2.6	2.5	2.5	2.5
45	compound A of formula I	5.0	5.0	-	1.0	1.5	3.0	3.0	5.0	5.0
	citraconimide compound A	5.0	-	5.0	1.0	1.5	3.0	3.0	5.0	5.0
	acrylate compound A	-	5.0	5.0	1.0	1.5	3.0	5.0	5.0	10.0
	sulfur	5.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0	5.0
50	Properties of vulcanized rubber composition (index)									
	peak temperature	110	110	103	103	104	108	108	111	111
	peak E'	113	120	112	109	111	118	120	123	124
	bottom temperature	99	100	91	99	97	94	91	89	87
	bottom E'	139	142	138	124	130	152	156	164	167
55	bottom E'/peak E'	123	119	124	113	118	129	131	134	135
	E' at 250 °C	140	142	148	125	132	158	162	171	173
	Tire									

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Table 5-8 (continued)

	Examples								
	124	125	126	127	128	129	130	131	132
constituting composition	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1	C-1
side reinforcing rubber	E-	E-	E-	E-	E-	E-	E-	E-	E-
bead filler rubber	124	125	126	127	128	129	130	131	132
runflat durability (index)	118	123	120	111	114	124	126	131	132

Table 5-9

	Examples						
	133	134	135	136	137	138	139
Rubber composition	E-133	E-134	E-135	E-136	E-137	E-138	E-139
Formulation							
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0
softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5
compound A of formula I	1.5	1.5	-	3.0	3.0	-	5.0
citraconimide compound A	1.5	-	1.5	3.0	-	3.0	5.0
acrylate compound A	-	1.5	1.5	-	3.0	3.0	-
sulfur	5.0	5.0	6.0	5.0	5.0	6.0	5.0
Properties of vulcanized rubber composition (index)							
peak temperature	104	103	101	107	107	102	110
peak E'	106	111	107	110	116	109	113
bottom temperature	100	101	97	99	100	93	99
bottom E'	119	122	118	132	134	130	139
bottom E'/peak E'	113	111	111	120	116	120	123
E' at 250 °C	117	121	124	133	134	140	140
Tire							
constituting composition	E-133	E-134	E-135	E-136	E-137	E-138	E-139
side reinforcing rubber	E-133	E-134	E-135	E-136	E-137	E-138	E-139
bead filler rubber	E-133	E-134	E-135	E-136	E-137	E-138	E-139
runflat durability (index)	137	141	136	161	162	161	172

Table 5-10

	Examples					
	140	141	142	143	144	145
Rubber composition	E-140	E-141	E-142	E-143	E-144	E-145
Formulation						
natural rubber	30.0	30.0	30.0	30.0	30.0	30.0
butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0
carbon black	60.0	60.0	60.0	60.0	60.0	60.0

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Table 5-10 (continued)

		Examples					
		140	141	142	143	144	145
5	softening agent	3.0	3.0	3.0	3.0	3.0	3.0
	zinc white	5.0	5.0	5.0	5.0	5.0	6.0
	stearic acid	1.0	1.0	1.0	1.0	1.0	1.0
	antioxidant	2.0	2.0	2.0	2.0	2.0	2.0
10	vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5
	compound A of formula I	5.0	-	1.5	3.0	3.0	5.0
	citraconimide compound A	-	5.0	1.5	3.0	3.0	5.0
	acrylate compound A	5.0	5.0	1.5	3.0	5.0	5.0
	sulfur	5.0	6.0	5.0	5.0	5.0	5.0
15	Properties of vulcanized rubber composition (index)						
	peak temperature	110	103	104	108	108	111
	peak E'	120	112	111	118	120	123
	bottom temperature	100	91	97	94	91	89
20	bottom E'	142	138	130	152	156	164
	bottom E'/peak E'	119	124	118	129	131	134
	E' at 250 °C	142	148	132	158	162	171
	Tire						
25	constituting composition						
	side reinforcing rubber	E-140	E-141	E-142	E-143	E-144	E-145
	bead filler rubber	E-140	E-141	E-142	E-143	E-144	E-145
	runflat durability (index)	174	171	159	200	206	220

Table 5-11

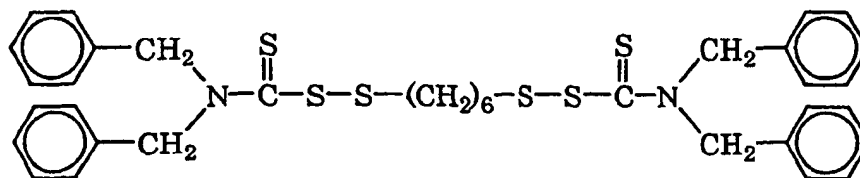
	Examples							
	146	147	148	149	150	151	152	153
35	Rubber composition	E-	E-	E-	E-	E-	E-	E-
		146	147	148	149	150	151	153
	Formulation							
	natural rubber	30.0	30.0	30.0	30.0	30.0	30.0	30.0
40	butadiene rubber	70.0	70.0	70.0	70.0	70.0	70.0	70.0
	carbon black	60.0	60.0	60.0	60.0	60.0	60.0	60.0

softening agent	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
zinc white	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
stearic acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
antioxidant	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
vulcanization accelerator	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
compound A of formula I	-	-	-	-	3.0	3.0	3.0	-
compound B of formula I	3.0	-	-	-	-	-	-	3.0
compound C of formula I	-	3.0	-	-	-	-	-	-
compound D of formula I	-	-	3.0	-	-	-	-	-
compound E of formula I	-	-	-	3.0	-	-	-	-
citraconimide compound A	3.0	3.0	3.0	3.0	-	3.0	3.0	-
citraconimide compound B	-	-	-	-	3.0	-	-	3.0
acrylate compound A	3.0	3.0	3.0	3.0	3.0	-	-	-
acrylate compound B	-	-	-	-	-	3.0	-	3.0
acrylate compound C	-	-	-	-	-	-	3.0	-
sulfur	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Properties of vulcanized rubber composition (index)								
peak temperature	109	109	108	106	107	108	108	108
peak E'	120	117	118	118	119	120	116	123
bottom temperature	94	94	93	93	93	94	94	94
bottom E'	156	152	151	149	155	155	147	163
bottom E'/peak E'	131	130	128	126	130	130	127	133
E' at 250 °C	162	159	156	154	160	161	154	168
Tire								
constituting composition								
side reinforcing rubber	E-	E-	E-	E-	E-	E-	E-	E-
	146	147	148	149	150	151	152	153
bead filler rubber	E-	E-	E-	E-	E-	E-	E-	E-
	146	147	148	149	150	151	152	153
runflat durability (index)	204	201	197	194	201	203	193	209

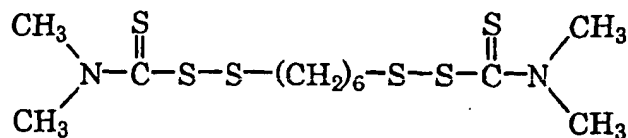
Note: E' = dynamic storage elastic modulus

Com. Ex. = Comparative Example

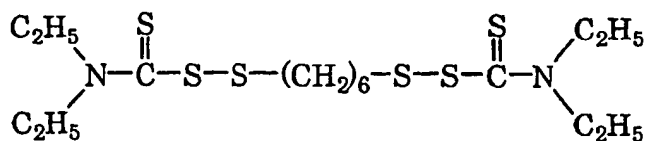
1) Compound A of Formula I: 1,6-bis(N,N'-dibenzylthiocarbamoyldithio)-hexane ("VULCUREN TRIAL PRODUCT KA 9188" of Bayer Akiengesellschaft)



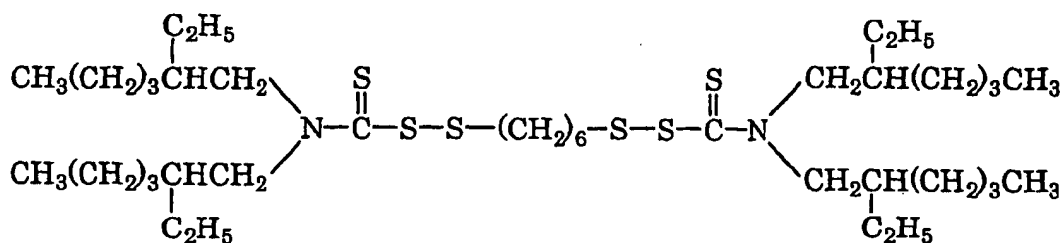
2) Compound B of Formula I: 1,6-bis(N,N'-dimethylthiocarbamoyldithio)-hexane (trial product)



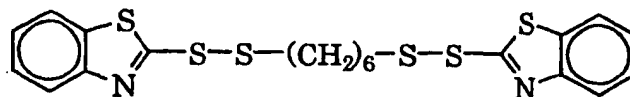
3) Compound C of Formula I: 1,6-bis(N,N'-diethylthiocarbamoyldithio)hexane (trial product)



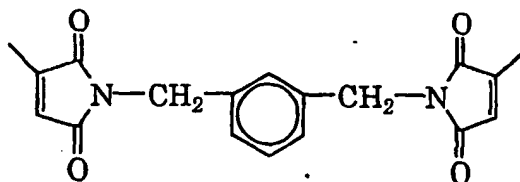
4) Compound D of Formula I: 1,6-bis(N,N'-di(2-ethylhexyl)thiocarbamoyldithio)hexane (trial product)



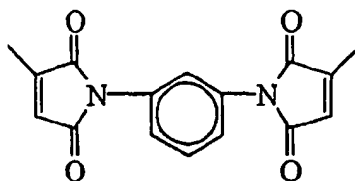
5) Compound E of Formula I: 1,6-bis(benzothiazolyldithio)hexane (trial product)



6) Citraconimide compound A: 1,3-bis(citraconimidomethyl)benzene (PERKALINK 900, trade mark of Flexis Co. Ltd.)



7) Citraconimide compound B: 1,3-bis(citraconimido)benzene (N,N'-m-phenylene-biscitraconimide) (trial product)



8) Acrylate compound A: "KAYARAD D310" (trade mark of Nippon Kayaku Co., Ltd.)

9) Acrylate compound B: "KAYARAD DPHA" (trade mark of Nippon Kayaku Co., Ltd.)

10) Acrylate compound C: "KAYARAD D330" (trade mark of Nippon Kayaku Co., Ltd.)

11) Constituting composition: Each tire member was made of the respective rubber composition shown in Table 5.

[0082] In Examples 73 to 102, the reinforcing layer for sidewall (side reinforcing rubber) was made of the rubber composition of the invention. In Examples 103 to 132, the rubber composition of the invention was used for forming the bead filler. In Examples 133 to 153, both the side reinforcing rubber and the bead filler were made of the rubber composition of the invention.

[0083] As seen from Table 5, the heat resistance was improved in the rubber compositions of the invention containing two or three kinds of compounds as the component B. In addition, the pneumatic tires having a bead filler or a reinforcing layer for sidewall made of the rubber composition of the invention is good in the runflat durability. In particular, the runflat durability is excellent when both the bead filler and the reinforcing layer for sidewall are made of the rubber composition of the invention.

Industrial Applicability

[0084] According to the present invention, a rubber composition having improved heat resistance is obtained, which is suitable, particularly, for a reinforcing rubber for tire sidewall portion and as a bead filler rubber for tires. A pneumatic tire having a reinforcing layer for sidewall portion or a bead filler both made of the rubber composition of the invention is excellent in the durability during the tire operation under runflat conditions and can be operated for extremely extended distances.

Claims

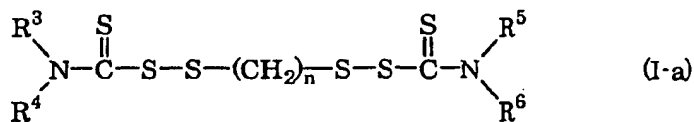
1. A rubber composition comprising (A) a natural rubber and/or a synthetic diene rubber and (B) at least one compound selected from the group consisting of a compound represented by the following Formula I:



wherein A represents an alkylene group having 2 to 10 carbon atoms, R^1 and R^2 each independently represents a monovalent nitrogen-containing organic group; a citraconimide compound; and an acrylate compound.

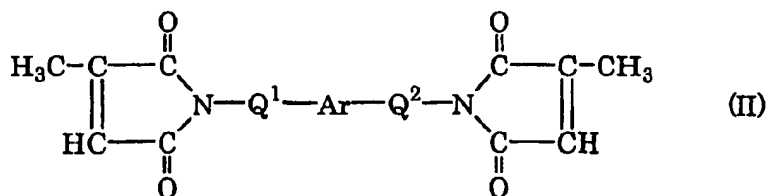
2. The rubber composition according to claim 1, wherein A in Formula I is hexamethylene group.

3. The rubber composition according to claim 1 or 2, wherein each of R¹ and R² in Formula I is a monovalent organic group containing at least one aromatic ring in addition to nitrogen atom.
4. The rubber composition according to any one of claims 1 to 3, wherein each of R¹ and R² in Formula I is a monovalent organic group containing =N-C(=S)- which bonds to a dithio group through its carbon atom.
5. The rubber composition according to claim 4, wherein the compound of Formula I is an α,ω -bis(N,N'-dihydrocarbylthiocarbamoyldithio)alkane represented by the following Formula I-a:



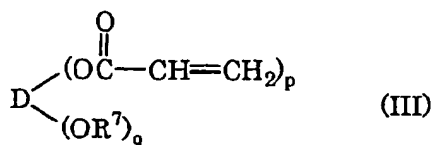
wherein each of R³ to R⁶ independently represents an alkyl group, an aryl group or an aralkyl group with the proviso that at least one of R³ and R⁴ and at least one of R⁵ and R⁶ represent an aryl group having 6 to 20 carbon atoms or an aralkyl group having 7 to 20 carbon atoms, and n is an integer from 2 to 10.

6. The rubber composition according to claim 5, wherein the compound of Formula I is 1,6-bis(N,N'-dibenzylthiocarbamoyldithio)hexane.
7. The rubber composition according to claim 1, wherein the citraconimide compound is a biscitraconimide compound.
8. The rubber composition according to claim 7, wherein the biscitraconimide compound is represented by the following Formula II:



wherein Ar represents an arylene group, and Q¹ and Q² each independently represents an alkylene group having 1 to 4 carbon atoms.

9. The rubber composition according to claim 7, wherein the biscitraconimide compound is 1,3-bis(citraconimido)benzene.
10. The rubber composition according to claim 8, wherein the biscitraconimide compound is 1,3-bis(citraconimidomethyl)benzene.
11. The rubber composition according to claim 1, wherein the acrylic compound is a multifunctional ester compound obtained by the reaction of a polyhydric compound with acrylic acid, or by the reaction of a polyhydric compound with acrylic acid and another carboxylic acid.
12. The rubber composition according to claim 11, wherein the acrylic compound is represented by the following Formula III:



wherein D represents a residue derived from a (p+q) valent polyhydric alcohol by removing a hydroxyl group and R⁷ represents a hydrogen or an acyl group other than acryloyl group, p is an integer from 2 to 10, q is an integer from 0 to 8, and p+q is 2 to 10.

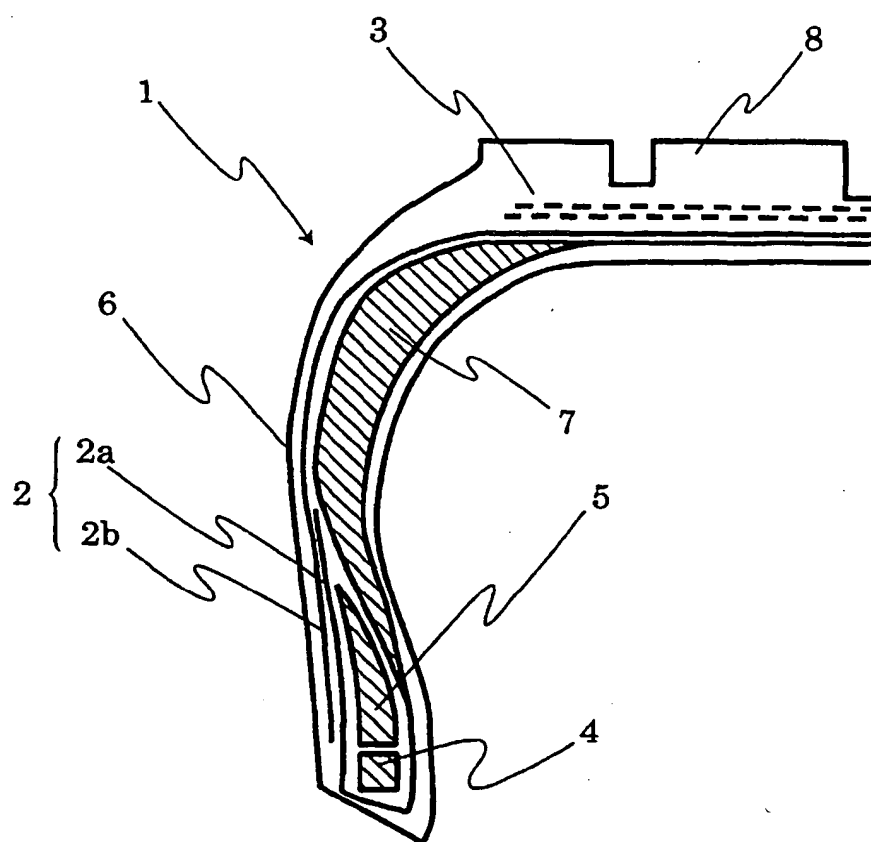
13. The rubber composition according to claim 12, wherein p is an integer from 3 to 6, q is an integer of from 0 to 3, and p + q is from 3 to 6.
14. The rubber composition according to claim 13, wherein the acrylic compound is a multifunctional ester compound obtained by the reaction of acrylic acid and a dipentaerythritol having 3 to 6 acryloyl groups.
15. The rubber composition according to claim 14, wherein the acrylic compound is an acyl-modified dipentaerythritol acrylate having 3 to 5 acryloyl groups.
16. The rubber composition according to any one of claims 11 to 15, wherein the rubber composition is produced by kneading a rubber with the acrylate compound at a maximum temperature of 140 °C to disperse the acrylate compound in the rubber.
17. The rubber composition according to any one of claims 11 to 15, wherein the rubber composition is produced by kneading a rubber with the acrylate compound at a maximum temperature of 120 °C to disperse the acrylate compound in the rubber.
18. The rubber composition according to any one of claims 1 to 17, which comprises (A) the natural rubber and/or the synthetic diene rubber and (B) at least two compounds selected from the group consisting of the compound represented by the following Formula I:



wherein A represents an alkylene group having 2 to 10 carbon atoms, R¹ and R² each independently represents a monovalent nitrogen-containing organic group; the citraconimide compound; and the acrylate compound.

19. The rubber composition according to any one of claims 1 to 18, wherein the component B is contained in an amount of 0.5 to 20 parts by weight based on 100 parts by weight of the component A.
20. The rubber composition according to claim 19, wherein the component B is contained in an amount of 0.7 to 15 parts by weight based on 100 parts by weight of the component A.
21. The rubber composition according to any one of claims 1 to 20, which is used for a bead filler rubber for tires.
22. The rubber composition according to any one of claims 1 to 20, which is used for a reinforcing rubber for tire sidewall portions.
23. A pneumatic tire having a pair of right and left ring bead cores, a bead filler provided radially outward of each of the bead cores, a carcass layer comprising at least one ply which comprises a plurality of parallel cords embedded in a coating rubber, a belt layer provided radially outward of the carcass layer, a tread portion provided radially outward of the belt layer, a pair of sidewall portions provided at both right and left lateral edges of the tread portion, and a reinforcing rubber layer provided at the sidewall portions, the reinforcing rubber layer for the sidewall portions and/or the bead filler being made of the rubber composition defined in any of claims 1 to 20.

Fig. 1



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/00752

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁷ C08L21/00, C08K5/36		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl. ⁷ C08L21/00, C08K5/36		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 04-091145, A (Huels AG), 24 March, 1992 (24.03.92), Claims; Par. Nos. 0016 to 0020, 0025	1-17, 19-20, 22-23
Y	Claims; Par. Nos. 0016 to 0020, 0025 & JP, 02-269749, A, Claims, page 3, lower left column, lines 4-7 & DE, 3941085, A1 & EP, 385073, A1 & BR, 9000870, A & EP, 432405, A1	1-23
X	EP, 540103, A1 (AKZO N.V.), 05 May, 1993 (05.05.93), Claims	1-17, 19-20
Y	Claims & JP, 05-214163, A, Claims & AU, 9227388, A & US, 5292815, A	1-23
X	JP, 63-150339, A (Bridgestone Corporation), 23 June, 1988 (23.06.88), Claims; Field of Industrial Application	1-17, 19-23
Y	Claims; Field of Industrial Application (Family: none)	1-23
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 09 April, 2001 (09.04.01)		Date of mailing of the international search report 17 April, 2001 (17.04.01)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)